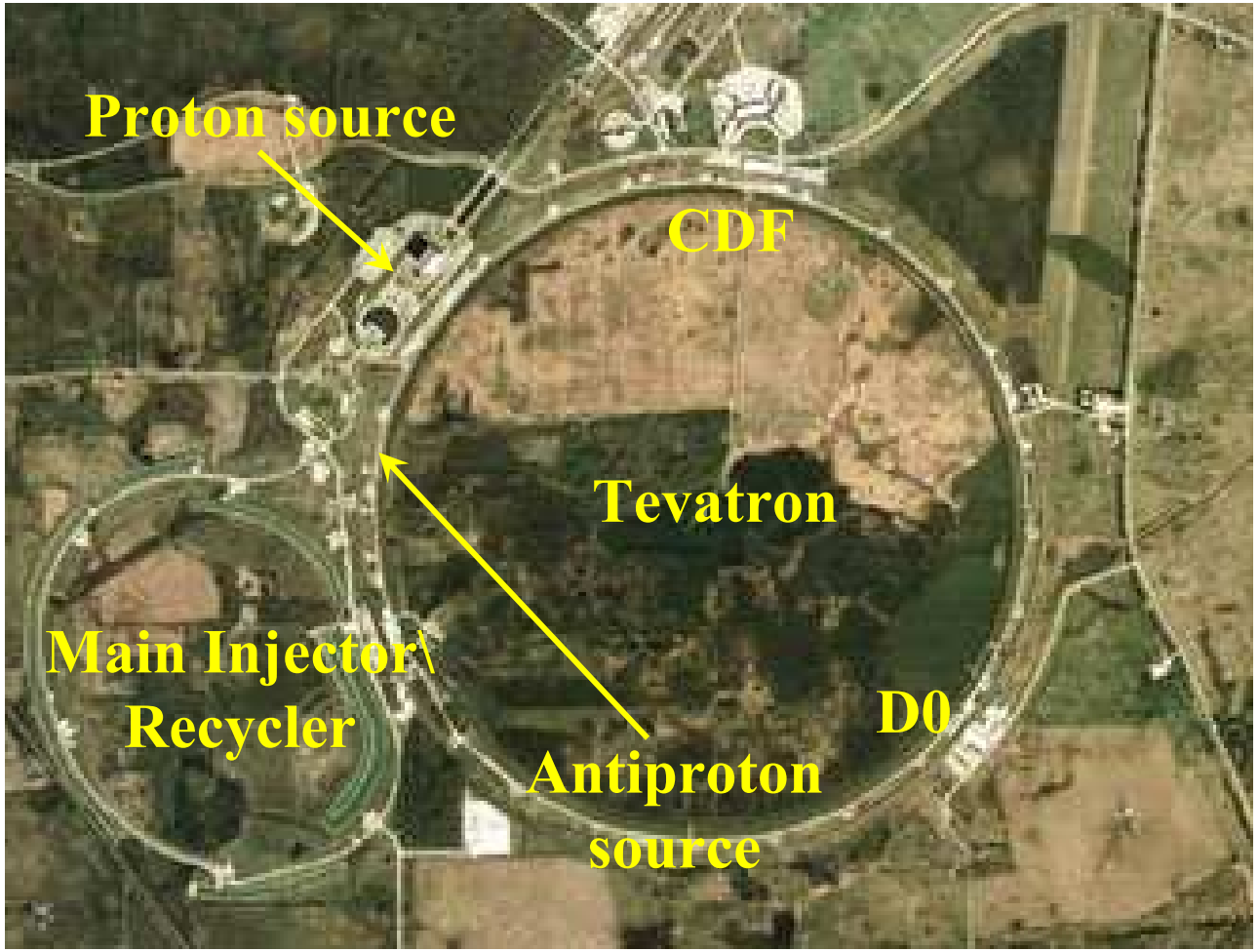
Current Operational Status of Recycler Ring

Cons Gattuso
Fermilab Accelerator Division

Fermilab Complex

- The Fermilab Collider is a Antiproton-Proton Collider operating at 980 GeV



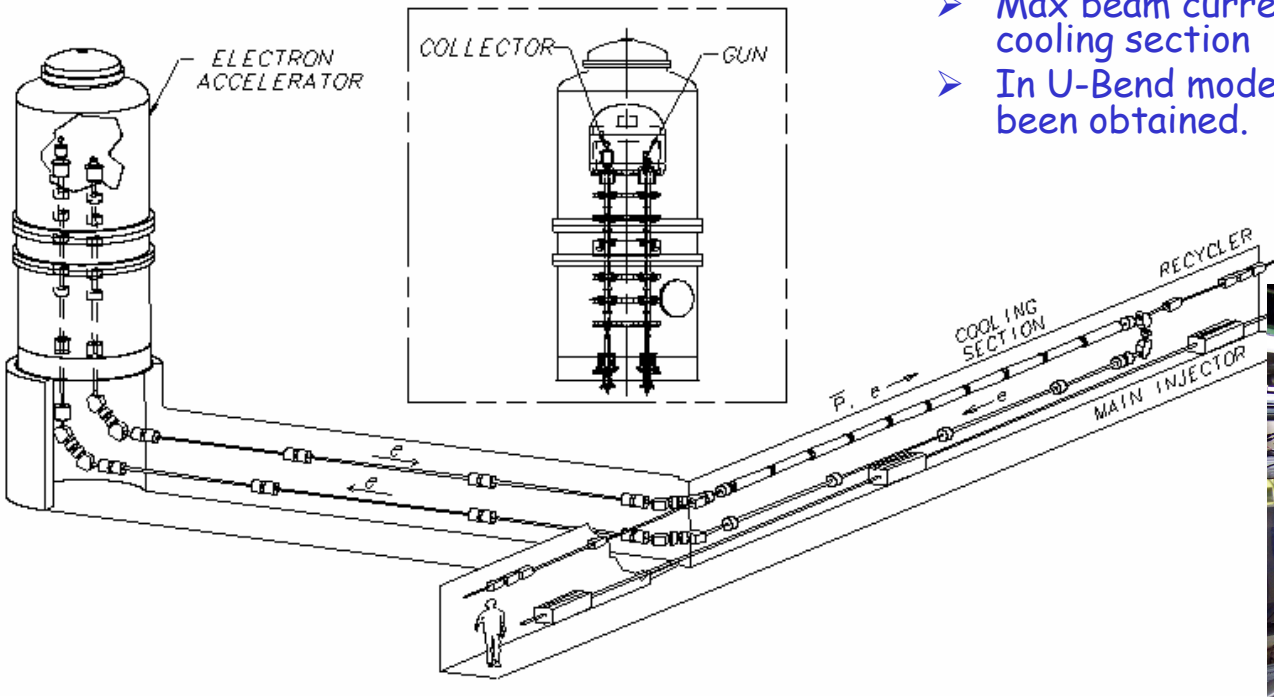
Recycler – 8.9 GeV/c storage ring

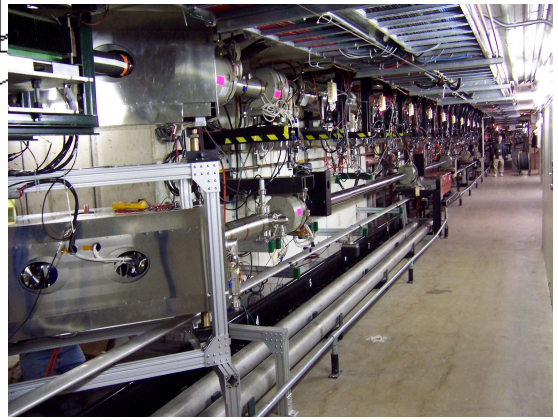
- At the end of August 2003
  - The Recycler was "on the ropes"
    - Lifetime was < 60hrs
    - Transverse emittance growth was 12π-mm-mrad/hr
  - Took drastic measures
    - Lengthened the Fall 03 shutdown to bake the entire Recycler
    - Instituted the Pbar Tax (Investment) to guarantee the Recycler adequate study time and access to the tunnel

- Recycler bake-out was extremely successful
  - Transverse emittance growth reduced by a factor of 10-20
  - Lifetime > 600 hours
- Recycler commissioning has progressed rapidly
  - Using the Recycler in "Combined Shots" operations makes it a luminosity enhancement
    - Operational January 2005
  - Transverse Damper commissioned August 2005
    - Stashes larger than 150×10^{10} Pbars now possible
  - Stand alone Recycler shots to the Tevatron (Sept 2005)
    - Stashes of 250×10^{10} Pbars in the Recycler
    - Average Coalescing eff 86%
    - Average Efficiency to collisions 77%
- Electron Cooling commissioned July 2005
  - Starting in August 2005, electron cooling is used on every Tevatron shot.

Recycler Electron Cooling

- The maximum antiproton stash size in the Recycler is limited by
  - Stacking Rate in the Debuncher-Accumulator at large stacks
  - Longitudinal cooling in the Recycler
- Longitudinal stochastic cooling of 8 GeV antiprotons in the Recycler is being replaced by Electron Cooling
  - Electron beam: 4.34 MeV – 0.5 Amps DC – 200μrad angular spread
  - Max beam current 730 mA Circulated in cooling section
  - In U-Bend mode currents of 1000 mA has been obtained.

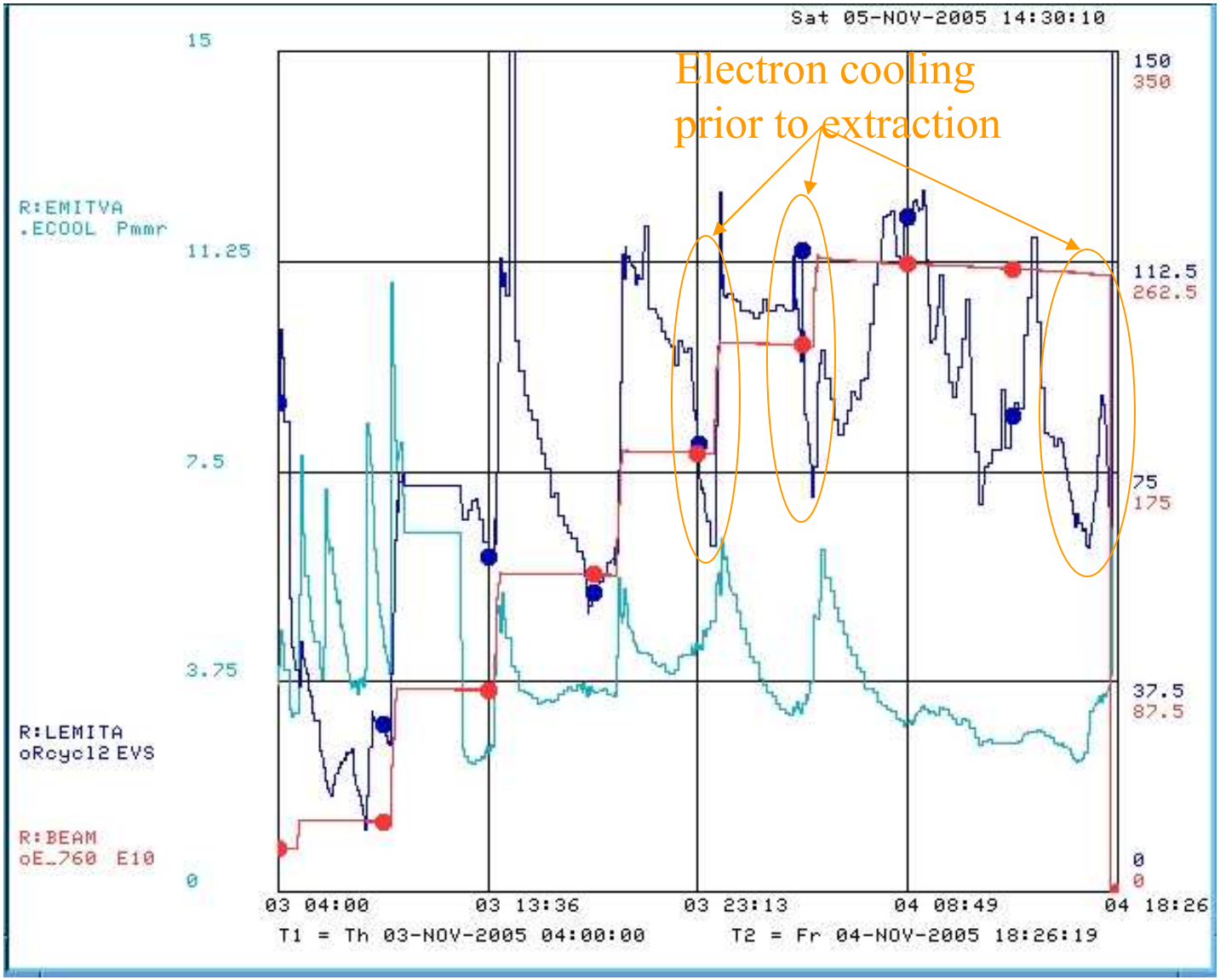




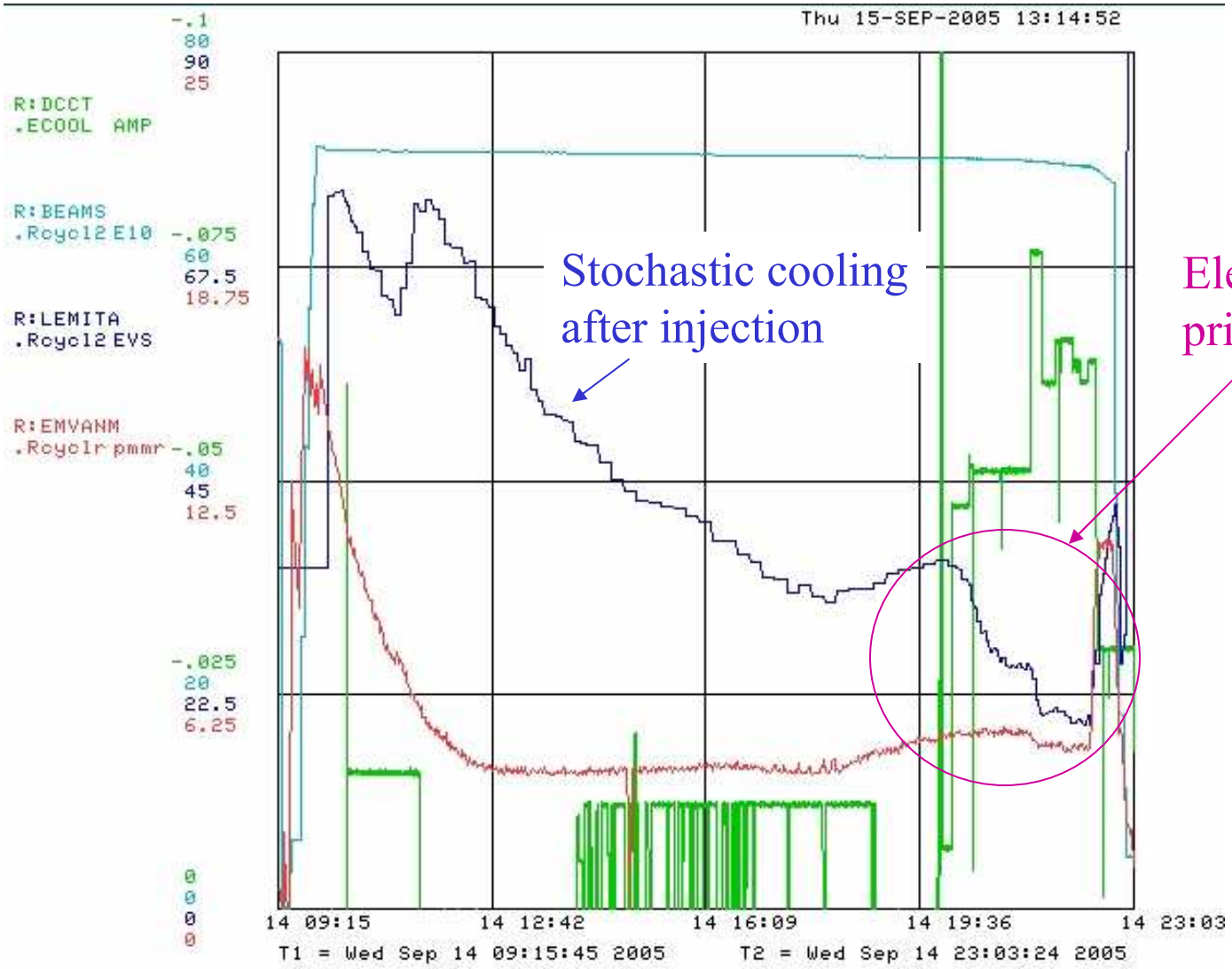
Recycler-Only Operations

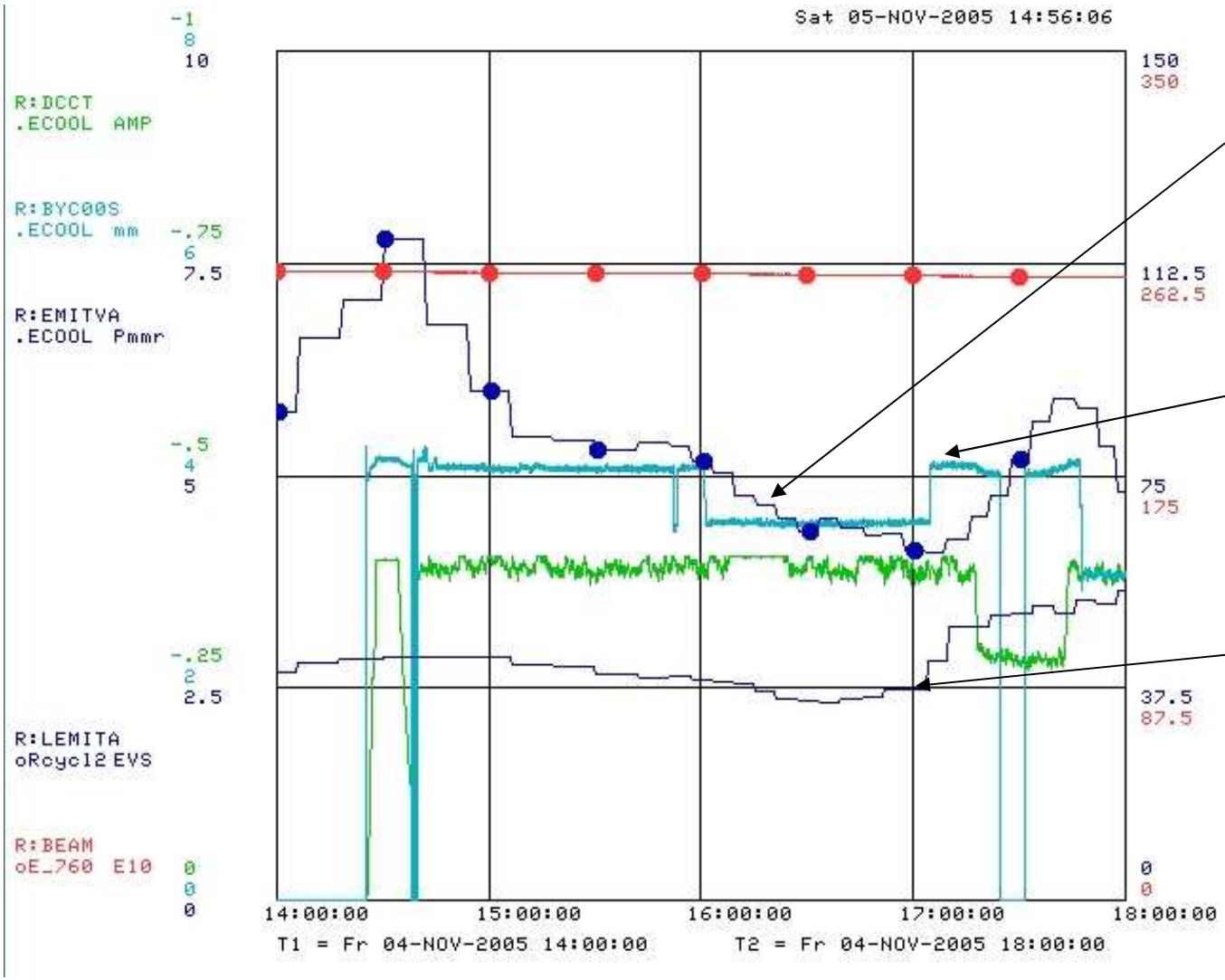
- With Electron Cooling operational and the transverse dampers commissioned, a Recycler stash size can now be increased to over 300x10^{10} Pbars
  - Turn around time from last transfer is about 1.5 hrs. (time can be reduced to about 45 mins – 1 hr.)
  - Transfer eff from ACC to RR with stash sizes >200 E10 is on the order of 90-92%
  - After Recycler only shots to the Tevatron the remaining is cooled and an additional transfers into the machine commence. (<= 1 hr.)

- The Collider complex is now transitioned from Combined Shot mode to Recycler-Only mode
  - Faster average stacking
  - We save about 45-60 mins of shot setup time
  - Smaller Pbar emittances in the TEV
  - Continue to stack Pbars in the Accumulator


Sat 05-NOV-2005 14:30:10
Electron cooling
prior to extraction
R:EMITVA
.ECOOL Pmmr
R:LEMITA
oRcycl2 EVS
R:BEAM
oE_760 E10
15
11.25
7.5
3.75
0
150
350
112.5
262.5
75
175
37.5
87.5
0
0
03 04:00
03 13:36
03 23:13
04 08:49
04 18:26
T1 = Th 03-NOV-2005 04:00:00
T2 = Fr 04-NOV-2005 18:26:19

Electron cooling in operation



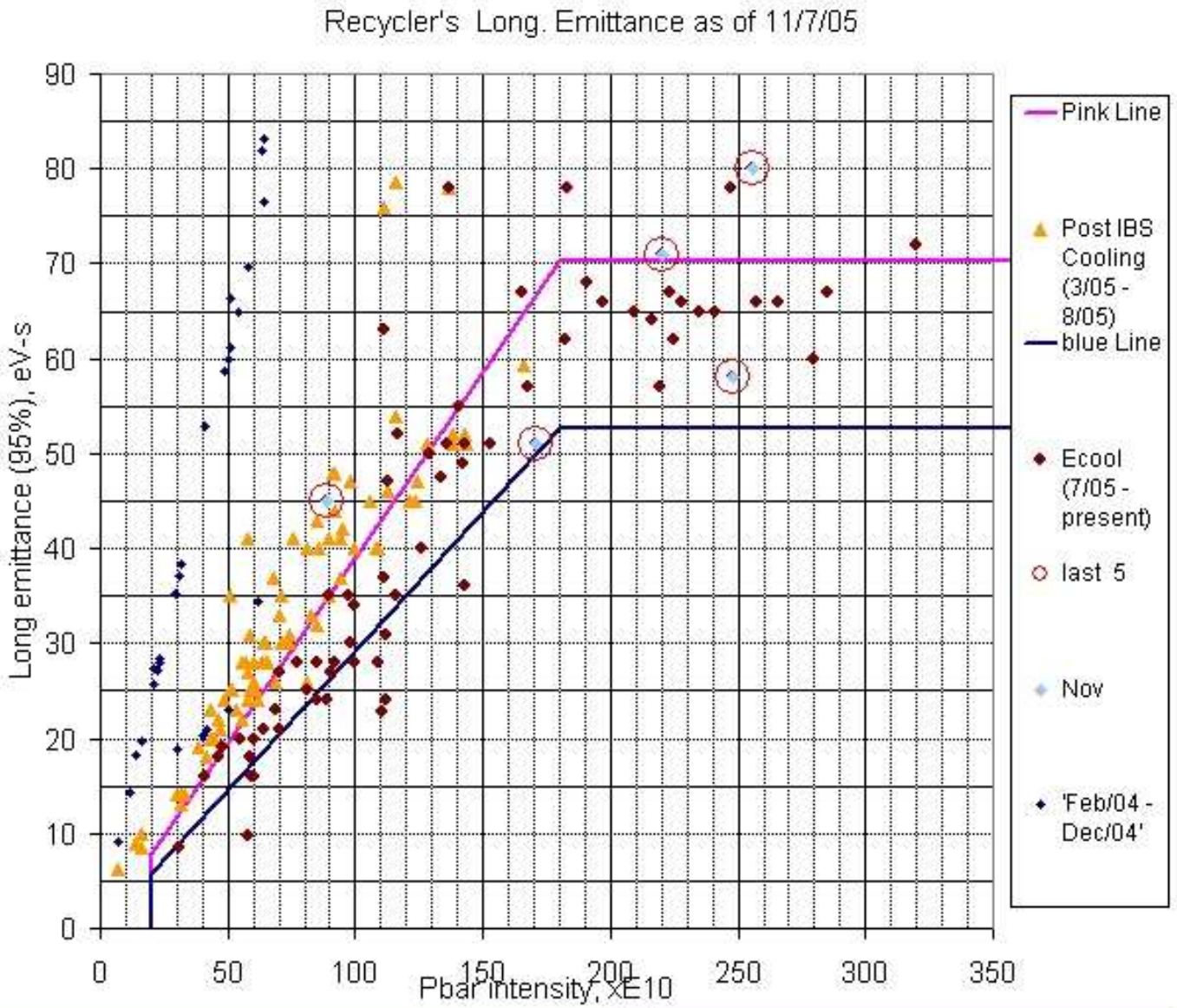


Long Emitt
60 eVsecs

Electron Beam
Position

Trans Emitt
2.5 mmmr

Intensity Vs. Longitudinal Emitt.



Final Recycler beam parameters

- Short term goals:
  - ✓ Recycler provides all Tevatron Pbars
  - ✓ 250×10^{10} Pbars → delivers $7e10^{10}$ Pbars per bunch in the Tevatron (75% (77%)efficiency to collisions, 36 bunches) - Bunch leveling is being worked on
  - ✓ Mining efficiency of 90% (95-97%)
  - ➢ Long. emittance (95%): 54 eV-s (58 eV-s)
  - ✓ Transverse emittances (n, 95%): 5 μm-rad
    - ➢ Shot with emitt range from 3-5 μm-rad
    - ➢ Smallest emitt of 2.8 μm-rad
    - ➢ Mild transverse growth rate during mining
  - ✓ Supports peak luminosities above 160×10^{30} $1/(cm^2 s)$
    Record Luminosity 10/31/05 store 4477 164 E10
- End of Run II:
  - ➢ Up to 600×10^{10} Pbars
    - Max Stash size of 329 E10 10/31/05
  - ➢ Same emittances